SMOKE AS AN INDICATOR OF GUSTINESS AND CONVECTION.

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Observation of the form of the smoke line issuing from a tall stack will give the aviator considerable information concerning the flying conditions in the lower 100 meters of air. The form of the smoke line issuing from a tall stack is a function of gustiness, turbulence, convection, and gravity. Aside from the effect of the wind, heated smoke will rise rapidly and later the particles may settle to the ground. Wind blows the smoke from the top of the stack and usually determines the angle of ascent. Gustiness in the wind varies the angle of rise and makes apparent waves. Local up-and-down movements either from turbulence produced by the irregularities of the earth's surface, or from local heat convection will accentuate the wavelike form produced by gustiness. Turbulence will dissipate the smoke quickly. There seem to be six or

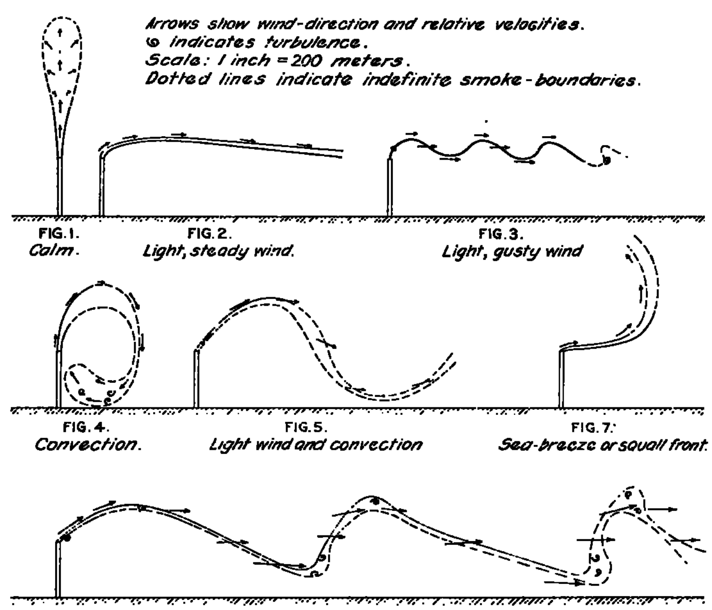

FIG. 6.
Moderate to brisk, gusty wind and convection

seven types of smoke form (see figs. 1–7). Let us consider each type, numbered according to the figures:

1. *Calm.*—In a calm, the smoke will issue vertically at an initial rate of two or more meters per second; but it will soon stop, as cooling, chiefly by the expansion of the heated gases and by mixture with the surrounding air, reduces the temperature of the smoke to that of the surrounding air, and allows the smoke particles to begin to fall.

2. *Light, steady wind.*—If there is a light, steady wind, the cooling by mixture goes on so rapidly that the smoke rises perhaps for less than a minute, and then very slowly falls. As may be observed often, the smoke will maintain itself in two proximate, parallel lines formed by the opposite, outward curls made when the smoke leaves the stack. At night, the smoke will travel miles and ultimately collect in a sheet marking the upper boundary of the nocturnal inversion, where the smoke particles in the undisturbed sheet fall but slowly through the dense air.

3. *Light, gusty wind.*—Figure 3 is theoretical, for gustiness is probably never found without vertical movement of the air. There are times, however, when vertical currents seem to be much less effective than horizontal changes in velocity in producing the observed smoke curve. When a gust blows across the top of the smokestack the smoke is blown off nearly horizontally and immediately begins to overtake the smoke which just left at a smaller velocity. In the lull which follows, the smoke may rise at an angle of 45 degrees and thus reach an elevation 20 or more meters above the smoke blown off in the gust. Another gust following sends the smoke off horizontally again. In this way, an apparent series of "waves" is formed, in which, however, there is no vertical motion except where the smoke issues from the stack. Because of relatively slow movement, the crests of these "waves" are slightly closer together than the troughs; and the more rapid movement of the troughs soon dissipates the smoke. As in the case of the steady wind, the smoke in this series of "waves" is slowly falling. The fall is relatively rapid if the density of the air is low and the air moist.

4. *Convection.*—On a clear day in summer when there is no progressive wind, there will be occasional light convectional breezes. The smoke may be caught in a local convectional circulation, rise, turn, and come down in a great curve even to the ground at the base of the smokestack. At College Station, Tex., the smoke from a 62-meter stack has been observed to descend at a rate of 2 meters per second. The condition illustrated in figure 4 was seen at noon one day early in September, 1918.

5. *Light wind and convection.*—As in the case of type 3, convection and a light wind without gustiness probably do not occur. Nevertheless, there are occasions when this type is to be observed in a nearly pure form. Here there is true wave motion, and the form of the curve is that which would result from combining the movements indicated in figures 2 and 4.

6. *Moderate to brisk, gusty wind and convection.*—Figure 6 illustrates the complexity of the smoke line as it is usually observed. Let us follow the development of this curve from that of a light steady wind. As convection on a clear day sets in shortly after sunrise, the lower air to a height of 50 or 100 meters may become disturbed within an hour and a half after sunrise, when the night temperature inversion is moderate, or within three hours when there is a strong inversion and relatively weak sunlight, as in autumn. The smoke sheet collected during the night loses its stratified character, becomes distributed throughout the air between the ground and the upper limit of convection, and slowly dissipates as convection brings in larger and larger volumes of fresh air. The smoke line itself as it issues from the stack and floats away assumes a wavy appearance when the upper limit of convection reaches that height, and so introduces vertical currents and makes the wind gusty. As convection goes still higher the downward components of the convectional circulation bring down greater wind velocities. So the apparent waves increase in wave length and in amplitude. A strong, somewhat downward current of air in a passing convectional cycle blows the smoke rapidly away and downward from the top of the stack. This smoke begins to overtake and run under the upward and more slowly moving smoke that went just before. Following this there is a lull in the wind and then another increase in wind velocity with an upward movement as the next cool gust forces the warm air in front of it to rise. The result is the formation of large "waves" in the smoke, waves having practically right angles at trough and crest, and having their steepest

faces toward the wind. Turbulence and the more rapid movement of both trough and crest than of the middle of the "wave" dissipates the smoke in two or three minutes. In windy, cloudy weather the form of the smoke is essentially the same, for the waves produced in the wind by the unevenness of the ground have vertical movements somewhat like those of local heat convection, though usually on a smaller scale.

7. *Sea breeze or squall front.*—On the front of a sea breeze, the smoke blows inland from the top of the smokestack, but is carried up and returned seaward aloft. This has been observed from Blue Hill, Mass., on several occasions. There is the same bow formation on the front of a thunder squall, though the turbulence is so much greater that the bow is not so long.

From these observations of smoke, it seems that in so far as smoke movements make air currents visible, smoke becomes a valuable indicator of the structure of the wind.

THE STRUCTURE OF GUSTS.[1]

By Major C. C. TURNER, R. A. F.

[Abstract.]

In a steady wind an airplane itself moves as if in a calm. Thus, if the wind is unsteady the number of gusts encountered in a given time will be the same whether there is a following or a head wind. And if, as anemometers indicate, gusts have no more abrupt onset than end, the effect of a gust from in front or of a lull from behind should be the same. Nevertheless, aviators say they can feel the difference between a head wind and a following one, and that they can climb fastest against the wind. Soaring birds apparently have the same experience. This would seem difficult to explain in any way other than that gusts begin more suddenly than they end. Apparently, we need more refined observations to show what the difference is.—*C. F. B.*

A VIRGINIA TORNADO.

By Prof. ALBERT W. GILES, University of Virginia.

[Dated: University, Va., Oct. 28, 1918.]

On October 29, 1917, a tornado occurred in the southern part of the State of Virginia that seems worthy of brief record. Gretna, a small village of some 200 inhabitants, situated in the north-central part of Pittsylvania County, 27 miles north of Danville, and on the main line of the Southern Railroad, was directly in the path of the disturbance and suffered severely. As a matter of fact, the destructive effects of the tornado were limited essentially to Gretna itself, its path being traceable but a short distance on either side of the town.

Tornadoes are very rare in Virginia. Greeley in his American Weather records less than five for the western part of the State between the years 1794 to 1881, and no published descriptions of this type of storm as occurring within the confines of the State are known to the writer.

In the study of the Gretna tornado no features new to tornadoes were discovered. It was simply a small storm of its class manifesting the usual phenomena. However, the date of its occurrence, very late in the autumn, is worthy of especial note as well as the lateness of the hour, 10:40 p. m.

Its path from the south-southwest toward the north-northeast may be traced continuously for a distance of about 2 miles, closely paralleling the Southern Railroad. In no place examined was the width of this path greater than 600 feet and locally it was but 150 feet wide. The accompanying map, figure 1, displays the direction of its course through Gretna.

The first evidences of destruction were found about one-fourth of a mile south of Gretna along the left side of the main highway. Here one or two trees had been twisted off and two straw stacks had been blown over. Passing beyond these the tornado crossed the main high-

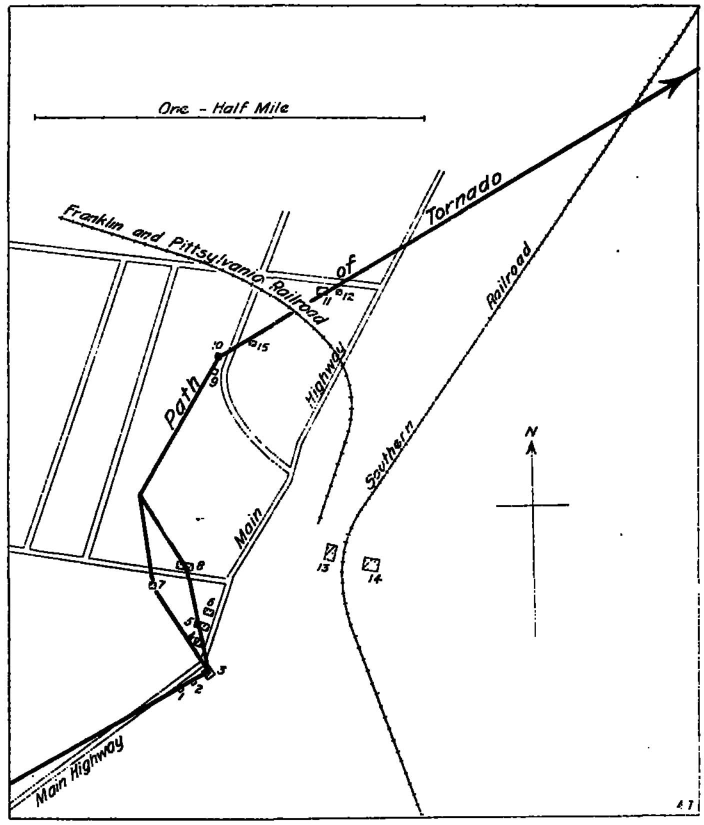

FIG. 1.—Sketch map of Gretna showing the path of the tornado through the village.
1. The Myers home.
2. The Easthan home.
3. Large tobacco warehouse destroyed.
4. Tobacco warehouse damaged.
5. Gretna Livery, Feed, and Sales stable.
6. Post office.
7. The Pickral home.
8. Powell's store.
9. The Eddie Bennett home.
10. The Dr. Powell's home.
11. The Christian Church.
12. The Adams home.
13. Southern Railroad station.
14. Virginia Hotel.
15. The J. E. Bennett home.

way and encountered the houses on the south side of the village. The first was a small frame structure (1, fig. 1) occupied by Mrs. Susie Myers. It was set back 3 or 4 feet and the back end rotated 8 feet from its normal position. Notwithstanding the unusual movements of her home Mrs. Myers preferred to remain in bed rather than to go out and face the storm. The next house (2, fig. 1), 100 feet north of the Myers home, was severely shaken but not damaged. The tornadic whirl apparently lifted over it only to descend with destructive violence on a large tobacco warehouse north-northwest 100 feet beyond. This building, 40 by 80 feet, substantially constructed of boards and three stories high, was totally destroyed (3, fig. 1).

[1] Aëron. Journ., London, 22:285-6, 1918.